UNIVERSITY - NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

ALVIN '86

A report on the program's status

Special ALVIN Study Committee

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Introduction

In September 1985, Dr. Robert W. Corell, Chairman of the ALVIN Review Committee for the University National Oceanographic Laboratory System, appointed seven persons to a Special ALVIN Study Committee. The appointees included Peter Brewer, Roger Cook, Daniel J. Fornari, Graham Hawkes, Peter Jumars, Dan Karig, Gary McMurtry, and Dirk Frankenberg, Chair. The study was envisioned as an opportunity "to gain an objective and critical overview of the total ALVIN program" at a time 20 years after inception of ALVIN operations but early in the period of such operations being mounted from RV ATLANTIS II. The committee was asked to complete its analysis early in 1986. The full charge to the study committee was as follows:

The Committee is requested to REVIEW, ANALYZE, and MAKE RECOMMENDATION concerning:

1. ALVIN supported science programs and activities, with particular but not necessarily only reference to:
   - o Past and present patterns in submersible support science, including accomplishments and limitations
   - o Strategies to facilitate and assure that ALVIN supported programs have scientific excellence
   - o Projections and trends (through the next decade) in submersible science, and their relationship to the ALVIN
   - o Patterns in funding support for ALVIN-supported science and operations
2. Particular reference but not limited to:
   - o Management/Operations of ALVIN
   - o Management/Operations of the ATLANTIS II
   - o At sea logistics and operations
   - o Technology within the ALVIN and A-II to support science, trends, developments, needs, and availability
3. ALVIN Program Planning, Oversight Procedures, and Review Policies with particular reference, but not limited to:
   - o Long range planning
   - o Annual scheduling process
   - o User access

- o Data archiving, storage, "ownership"

- o ALVIN Review Committee (ARC) policies, procedures, practices, membership, and scope of responsibilities

- o Roles and relationships with federal agencies

4. Additional issues:

- o Relationship of ALVIN program and Navy submersibles, particularly, SEA CLIFF, TURTLE, NR-1, DOLPHIN.

- o Cooperation with foreign programs

- o New construction needs, submersibles and support systems

- o Review S^3 Study

I. Review and Analysis of ALVIN Supported Science Programs and Activities

Summary

ALVIN has been the most important tool for manned exploration of the sea floor since the early 1970's. The bulk of its activities have been in support of geological and biological research, but it has also been involved in important studies of hydrothermal vent geochemistry, and, to a lesser extent, engineering, testing, and searches. The early scientific contributions based on ALVIN dives were summarized in the Submersible Science Study (UNOLS, 1982) by geographic area studied (mid-ocean ridge, ocean basin floor, continental margin, water column), and topic (baseline environmental studies). In the last five years ALVIN based science has further elucidated geological and ecological processes of the sea floor through use of remote sensing, direct observation, new sampling tools, and field experiments. The use of ATLANTIS II as the ALVIN support ship has made possible projects of increased complexity and sophistication since 1983; the existence of the Sea Beam bottom mapping system on ATLANTIS II has vastly improved scientific output by providing improved context for ALVIN dives and increasing the scientific efficiency of dive time. These improvements are reflected by the fact that 54% of the scientific dives between 1980 and 1985 have been made in the 37% of the time available since inception of A-II-ALVIN operations.

ALVIN science has been excellent, a situation created by rigorous scientific peer review of ALVIN proposals, mission agency review, and a special ALVIN appropriateness analysis conducted by the ALVIN Review Committee of UNOLS. There seems little doubt that excellent science will continue from ALVIN during the next decade.

I. Review and Analysis of ALVIN Supported Science Programs and Activities

Discussion

a. Past and present patterns in submersible support science, including accomplishments and limitations

During the past five years, marine scientists have gained a detailed perspective and knowledge of sea floor processes in various plate settings through field experiments which have employed the latest advances in remote sensing and submersible tools. Many of these field studies have utilized the submersible ALVIN to gain a visual perspective of the sea floor terrain so that the variety of remote sensing data (Sea Beam multibeam sonar, side-looking sonar) could be properly interpreted in terms of field relationships and in situ collected samples.

At the present time ALVIN represents a unique oceanographic research tool that allows scientists reliable access to sea floor study areas or bottom-moored experiment arrays at depths of 4000 m or less. Even with the high degree of sophistication of today's remote sensing sonar tools, the eyeball perspective and maneuvering/sampling capability that ALVIN provides for the study of ocean floor geologic structure and morphology, sediment dynamics, hydrothermal vent chemistry and dynamics, and biologic processes, are essential to: 1) testing scientific models based on remote sensing data, 2) correctly interpreting those data, and 3) the collecting of precisely located samples.

Pre-1983 ALVIN/LULU Accomplishments

Prior to 1983 ALVIN was a critical element of field investigations designed to understand the first-order morphology, structure, geochemical characteristics and tectonics of slow and intermediate spreading-rate mid-ocean ridge segments, and transform zones. One of the most important roles that ALVIN has played in oceanographic research during the past decade has been in locating and sampling sea floor hydrothermal vents. The low and high-temperature geochemistry of these vents has revolutionized our understanding of ocean chemical balances, hydrothermal circulation processes and biochemical processes that sustain vent ecosystems. ALVIN also played a major role in the investigation of continental margin features such as submarine canyons, submarine thrust systems and mass-wasting processes, and sea floor bedforms and sediment dynamics associated with abyssal geostrophic currents. In addition, ALVIN has been instrumental in allowing "mission oriented" biological programs to make detailed observations and collect representative samples of ocean floor epifauna and infauna so that benthic population structure, distribution and colonization rates could be assessed. The biological studies have also contributed to our understanding of upper sediment mixing and chemical fluxes resulting from bioturbation.

The distribution of ALVIN dives by major discipline during the period 1964 to 1985 is shown on Figures 1 and 2. Generally the submersbile has been used principally for geological or biological research during the past 21 years of operation.

The remaining dives have largely been dedicated to training, testing, or engineering related studies.

During the pre-1983 period, ALVIN operated exclusively from the R/V LULU, a twin-hulled vessel with a launch/recovery elevator system, limited scientific personnel space, no ancillary research ability and a top speed of 6-7 knots in moderate seas. LULU was required to have an escort vessel for all expeditions which required either ancillary research capability (camera towing, dredging, survey work) or in open ocean dive areas located at distances greater than 30 miles from port. The physical characteristics of LULU, its inability to effectively transit long distances to reach scientifically interesting but remote portions of the ocean, and its lack of adequate launch and recovery capability in high sea states, resulted in a weather-limited operational schedule restricted to accessable portions of the Mid-Ocean Ridge (MOR) system or study areas logistically proximal to either an east coast (WHOI) base of operations or west coast ports with adequate facilities.

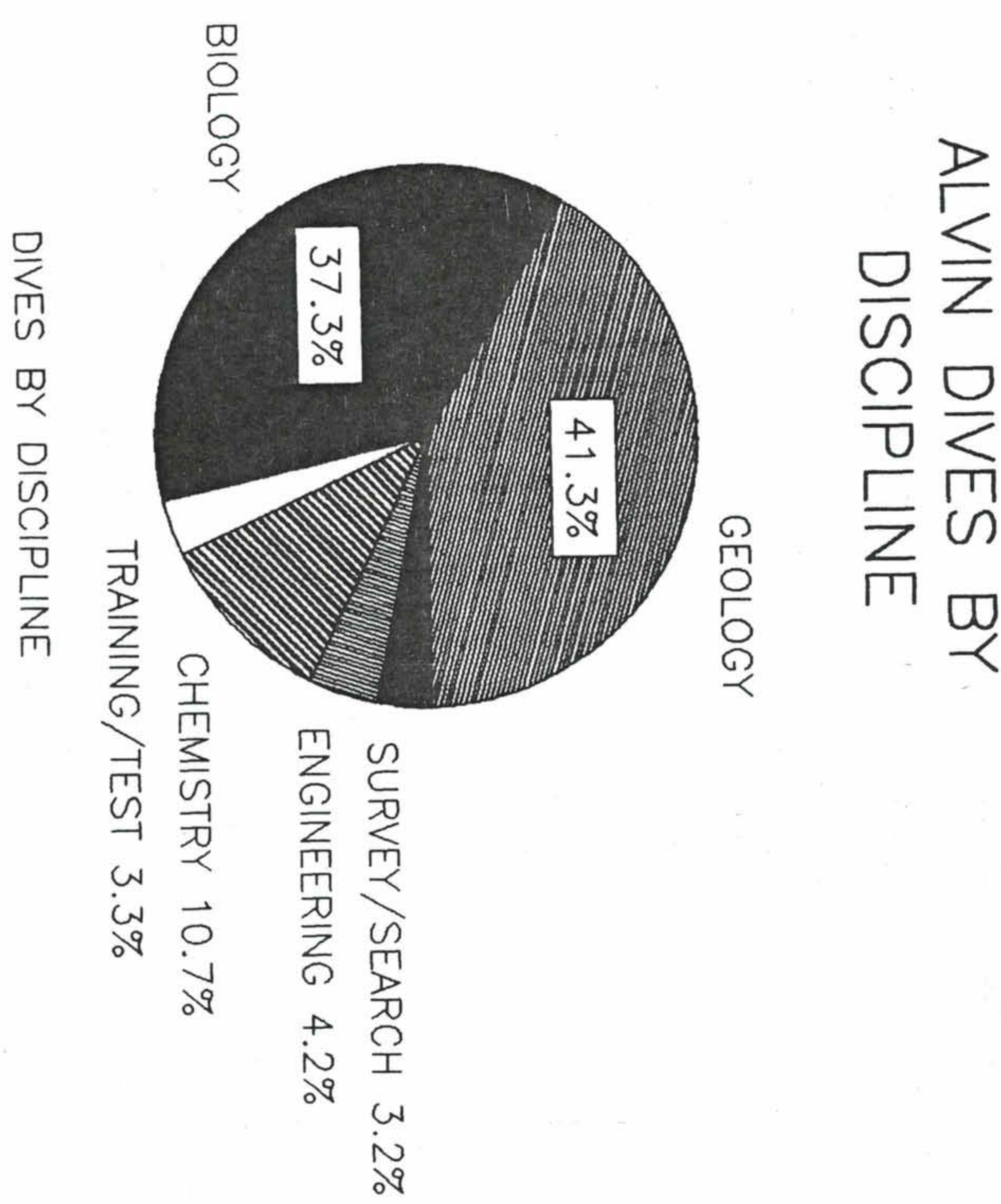
Even with these formidable handicaps the ALVIN/LULU team carried out a full spectrum of critical scientific studies from 1965 to 1983 which helped to propel the marine sciences into new dimensions of understanding the geological, tectonic, chemical and biological processes operating on and within the sea floor.

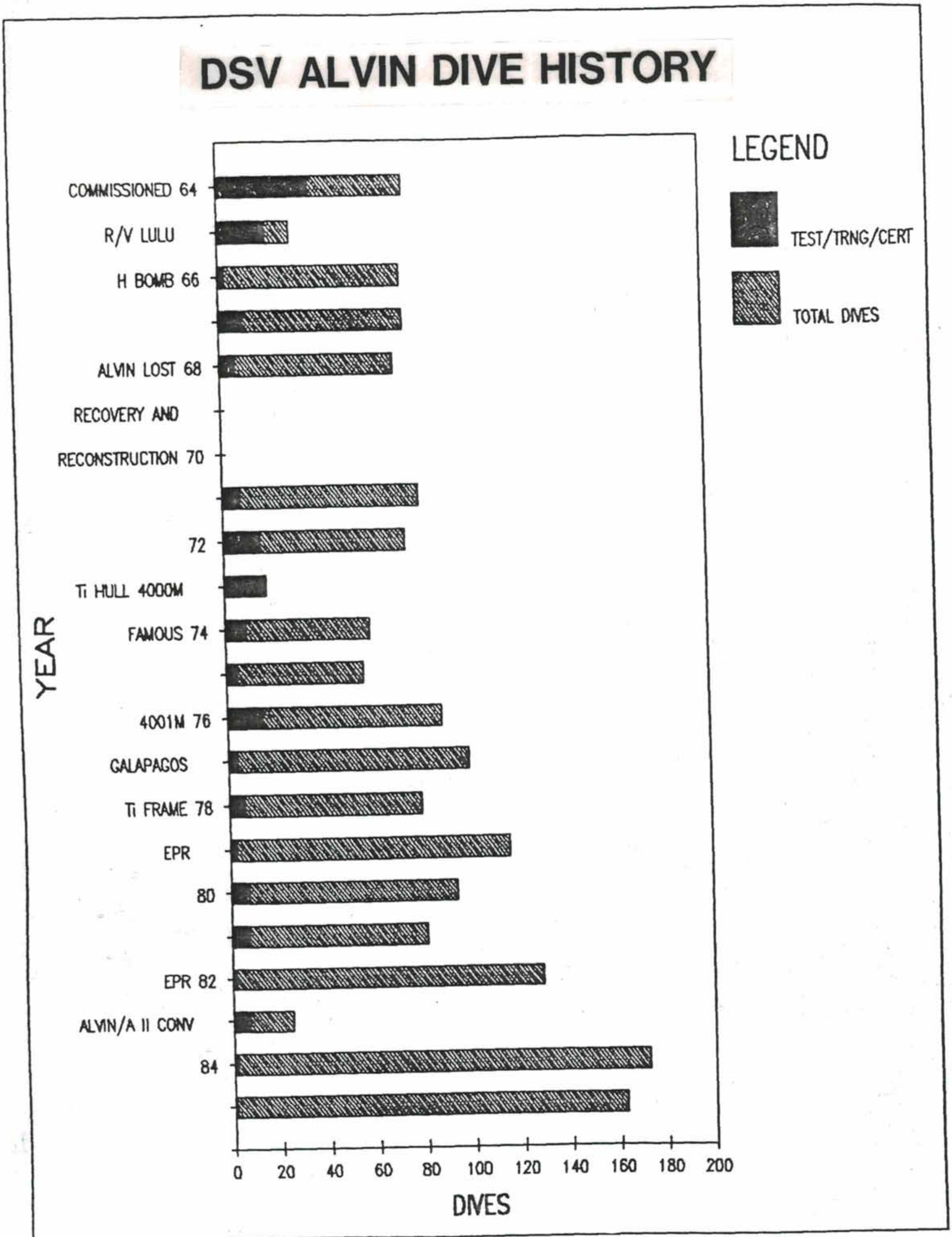
Post-1983 ALVIN/ATLANTIS-II Configuration

As a result of the limitations of R/V LULU as a support vessel for such an important research tool as ALVIN, and because of the need to incorporate the ability to carry out other submersible-compatible ancillary programs from the support vessel, the R/V ATLANTIS II (A-II) was overhauled and converted to the support vessel for ALVIN. The resultant package has been a dramatic success, fully supporting the wisdom of the A-II conversion. The special ALVIN study committee commends those involved in that decision.

One of the most effective elements of the A-II conversion entailed installation of a moveable A-frame and winch system that launches and recovers ALVIN off the stern. This system utilizes a design that has been used in the offshore oil industry to launch service equipment for sea floor platforms and components, and it has been tried and proven under the harshest environmental conditions.

Figure 1


ALVIN DIVES BY DISCIPLINE
GEOLOGY
41.3%
BIOLOGY
37.3%
SURVEY/SEARCH 3.2%
ENGINEERING 4.2%
CHEMISTRY 10.7%
TRAINING/TEST 3.3%
DIVES BY DISCIPLINE


DSV ALVIN DIVE HISTORY
LEGEND
TEST/TRNG/CERT
TOTAL DIVES
COMMISSIONED 64
R/V LULU
H BOMB 66
ALVIN LOST 68
RECOVERY AND
RECONSTRUCTION 70
72
Ti HULL 4000M
FAMOUS 74
4001M 76
GALAPAGOS
Ti FRAME 78
EPR
80
EPR 82
ALVIN/A II CONV
84
YEAR
0
20
40
60
80
100
120
140
160
180
200
DIVES

A-II has a standard array of oceanographic facilities (deep sea trawl winch, hydro winch, dredges, piston corers, underway geophysics) and accommodates a scientific party of 20, ships' crew, as well as the ALVIN operations group. A-II is also equipped with the Sea Beam, a multibeam sonar system that produces machine-contoured sea floor maps in real-time with a vertical resolution of approximately 10 m. On board computers also permit post-survey navigation correction and replotting of Sea Beam bathymetric data.

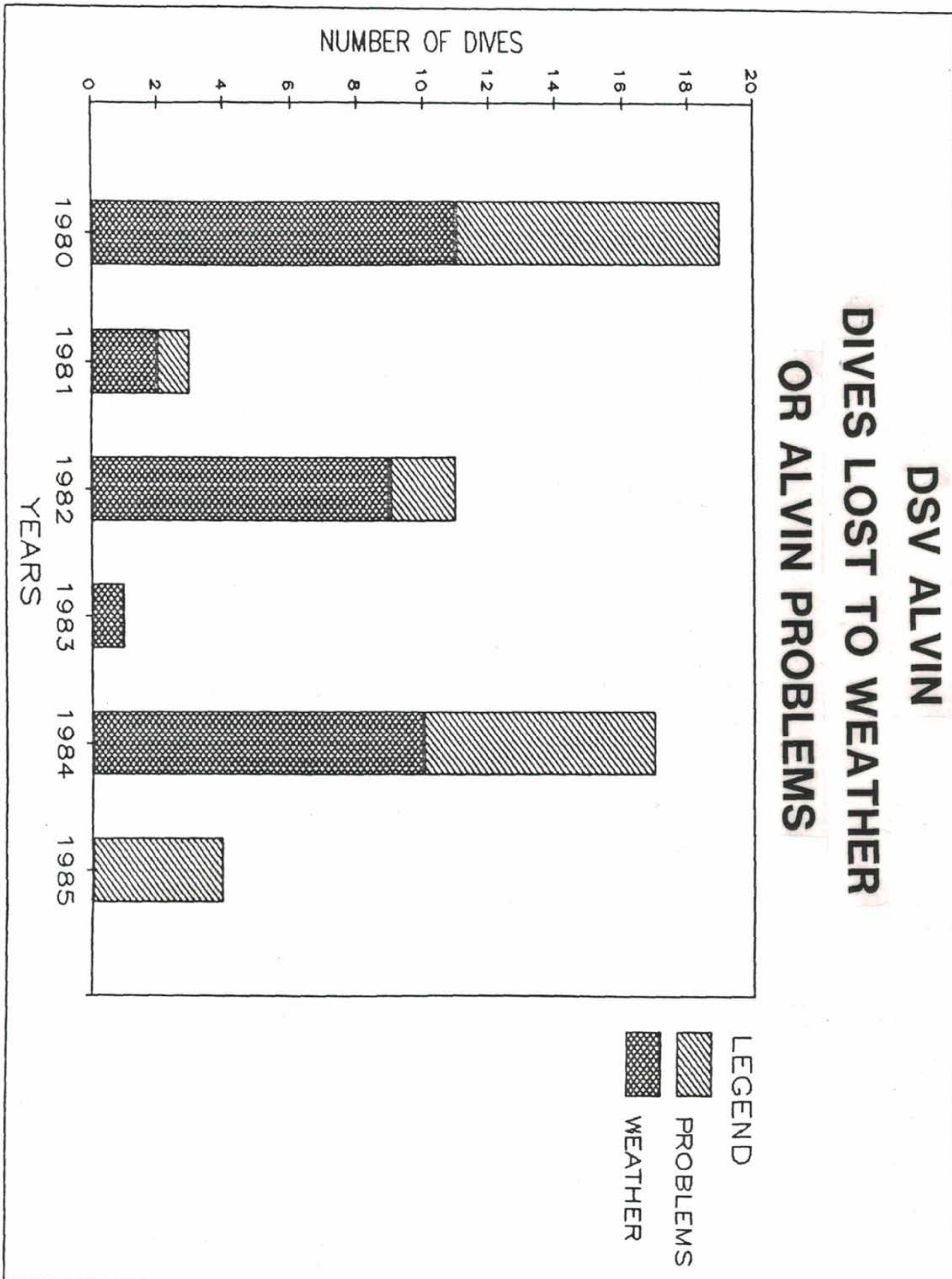
Post-1983 ALVIN/A-II Operations

The successful conversion of A-II to the ALVIN support ship has resulted in a vastly improved system with which to conduct submersible field programs, integrated multibeam bathymetric surveys and ancillary science programs. To a great extent the success of the ALVIN operations in the post-1983 period reflects the ability of the A-II to support a greater number of science dives per year over a wider geographical range and with a more sophisticated array of shipboard systems. In particular, the Sea Beam on A-II allows scientists to accurately locate ALVIN dives within an existing high resolution bathymetric database. A-II's vastly improved transit speed, logistical range and ability to launch and recover ALVIN in sea states up to State 4 has allowed ALVIN to investigate previously inaccessable areas such as the Juan de Fuca and Gorda Ridges, and will allow it to explore back arc basin ridges and seamounts in the western Pacific in the next few years.

The benefits of the A-II launch and recovery system are easily documented in the dive statistics shown in Figure 3. ALVIN has carried out more dives per year over a greater geographical range and with a higher success rate than that of the ALVIN/LULU years.

The depth and breadth of the ALVIN operations team has also increased greatly since the A-II conversion. The steady-state number of pilots during the ALVIN/LULU era was usually three. The number of skilled pilots increased steadily during 1984 and 1985 to the point where there are now seven pilots and two pilots-in-training. This has greatly enhanced the science output of dive programs because the pilots are better rested between dives during long diving programs, hence their effectiveness in maneuvering the submersible and sampling is not impaired by fatigue. In addition, the greater number of pilots also allows for more frequent shore-based pilot rotation which provides a more rational vocational existence, greater interface between shipboard and shorebased personnel and will probably result in a longer residence time for pilots in the program. All of the above can only help to increase the efficiency and expertise of the seagoing operations group.

Figure 3


DSV ALVIN
DIVES LOST TO WEATHER
OR ALVIN PROBLEMS
NUMBER OF DIVES
0
2
4
6
8
10
12
14
16
18
20
1980
1981
1982
1983
1984
1985
YEARS
LEGEND
PROBLEMS
WEATHER

Sea Beam

Almost all of the ALVIN dive programs carried out since 1983 have relied heavily on the availability of an existing multibeam bathymetric data base to identify important geological and structural sea floor features to be explored with ALVIN. In addition, many of these geologically focused programs benefited from side-looking sonar data (either Sea MARC I, Sea MARC II, Deep Tow or GLORIA) acquired over large swaths of sea floor (usually 5-10 km in the case of Sea MARC I and II, respectively). These data allowed small-scale (10 m or less relief) sea floor features to be mapped over large areas so that spatial field relationships could be established and investigated with subsequent site-specific ALVIN dives.

The importance of Sea Beam in the context of current ALVIN dive planning and execution cannot be overstated. It has permitted numerous investigators who have spent years collecting a high resolution data base to accurately reposition A-II within that data base. It has also been possible to employ side-looking sonar to assist in positioning ALVIN dives. Programs that have used this capability have been able, in many cases, to dispense with deploying a bottom-moored transponder navigation system because it has proven more effective to utilize the Sea Beam and side-looking sonar data to position and navigate the submersible. In these cases the final smoothed ALVIN dive track was assembled by integrating the time versus depth and heading data and visual observations from ALVIN with the existing Sea Beam data and either pre- or post-dive Sea Beam swaths over the dive area.

The above described method of positioning and navigating ALVIN has revolutionized the potential of ALVIN to effectively carry out a field program in a large survey area while maintaining a high-degree of precision in positioning the submersible. Prior to this use of Sea Beam, ALVIN had to rely on the ALNAV, long-baseline, bottom-moored transponder system which is costly to operate (both person-hours and loss of equipment) but more importantly took valuable time away from possible ALVIN diving. In addition, it was usually not practical or logistically possible to deploy and recover several ALNAV nets if the ALVIN dives were to cover a large area of sea floor. Recently, successful field programs have been carried out along large areas of the Clipperton transform and at the East Pacific Rise (EPR) at either end of this transform.

The Sea Beam has also greatly improved the ability to carry out ancillary operations such as dredging and deep sea camera tows, and facilitated the reduction of navigation data from those programs. Correlative Sea Beam swaths over dredge paths and camera traverses provide important constraining data which improve data analysis and enhance interpretations.

Post-1983 ALVIN Accomplishments

ALVIN has conducted over 363 dives since the A-II conversion. Scientifically, ALVIN diving during this time period has addressed problems in submarine geology, geochemistry and biology.

Geology: In geology, ALVIN based scientific observations and experiments have elucidated the following phenomena:

1. Ocean floor structure and tectonics of medium-slip rate transform faults and relationships between accretionary processes and transform processes at ridge/transform intersections,

2. Propagating ridges in the Galapagos area, the structural and tectonic seafloor fabrics developed, fine-scale magnetic properties of the seafloor, and detailed geochemistry of propagating ridge tips,

3. Young and old seamounts, their morphology and structural evolution including caldera development, and the geochemical evolution of seamount lavas and associations between ridge crest magma chambers and seamount magma chambers,

4. Detailed mapping of structural features on the Gorda and Juan de Fuca ridges as well as mapping and sampling sulfide deposits in the Galapagos and Juan de Fuca ridges,

5. Sediment dynamics and continental margin current processes off the U.S. southeast coast, and

6. Delineation of tectonic and sedimentary processes at active subducting margins.

Geochemistry

In geochemistry, ALVIN provided that tool through which the hot springs (hydrothermal vents) on the crest of the Galapagos were discovered. This discovery revolutionized ocean geochemistry and demonstrated beyond all doubt, that ALVIN is an indispensable research tool as unique as the drilling ship. While chemical anomalies can be "caught" in the water column above the vents, only ALVIN can sample the undiluted hydrothermal waters. This has proved crucial for study of these potentially ore-forming fluids which are seriously compromised chemically by mixing with ambient seawater. In addition, ALVIN can make temperature measurements in the throats of hydrothermal vent orifices and can sample the hydrothermal precipitates that form them. The study of the hot spring systems on the ridges of the eastern Pacific over the past eight years has led to revolutionary new understanding of the mechanisms of ore deposition and sharpened our insights on the processes of formation and evolution of the oceanic crust and its physical properties.

In other ridge crest studies ALVIN has had great success in sampling discrete outcrops particularily for the collection of unusual samples. When the dives are placed in the context of the Sea Beam coverage discussed earlier it becomes obvious why it is possible to do sea floor mapping and sampling at a level of detail comparable to that possible on land. Discrete sampling for geochemical analysis requires this level of detail.

The first use of ALVIN's unique capablilities in sedimentary geochemistry was for the collection of completely undisturbed core tops. Since the pilot can see the penetration of the transparent plexiglass core, the disruptive effects of the "bow wave" and of lateral motions can be eliminated. This has been extremely important for studies of pore water diffusion where the calculated fluxes are determined by gradients in the immediate sub-surface often lost or ambiguously sampled using ship-deployed systems. ALVIN is now being used to deploy increasingly sophisticated in situ pore water and sediment samplers where "eye ball" control is essential. Much work is being done on the seasonally ephemeral "fluff layer" composed of highly reactive, recently delivered planktonic material that appears to represent an intermediate environment for reactions different from those going on purely in the water column or the sediments.

Biology

High points of ALVIN-conducted biology and biological oceanography are divided between hydrothermal vent environments and soft sediments. At the vents, ALVIN has played a key role in finding and recovering components of luxuriant, previously unknown faunas. It allowed recovery in sufficently good physiological condition to discover and repeatedly verify that symbiotic bacteria are intermediaries in the nutrition of these spectacularly large and locally abundant invertebrates. Both radiochemical dating and mark-and-recapture studies reveal rapid growth and death of these large organisms, in contrast with the much longer lifespans thought to prevail for the tiny organisms of the abyssal sea floor. Precise spatial sampling with ALVIN (in fluid jets emanating from vents) combined with geochemical indicators of mixing and with cultures of returned microbes revealed that these organisms can grow well above $100^{\circ}C$ at deep-sea pressures and led to the hypothesis that they may exist at any temperature and pressure combination that allows water to remain in the liquid phase. The microbes proved to belong to the archaebacteria, the oldest known form of life on earth, leading to the idea that conditions at vents (strong gradients in temperature and chemical energy) resemble those in which life began.

On and over the soft-sediment deep-sea floor, other discoveries, perhaps less spectacular in the public eye but very important to the understanding of this most extensive environment, were made. Bacteria that grow better under greater pressure than atmospheric were sampled and documented, discrediting the idea that pressure precludes optimal growth in all bacteria. Size-selective mixing by bottom-living organisms was clearly demonstrated experimentally by deployment and resampling of closely size-graded particles. This finding has broad implications for micropaleontological and geochemical interpretation. Rapid colonization rates of denuded sediments by macroscopic organisms were observed for the first time, due at least in part to the care with which ALVIN manipulations were able to simulate natural disturbance events. More importantly for the theory of deep-sea community maintenance, but again unlike prior results, some dominant members of the background community showed opportunistic responses to denuded sediments.

Unusual faunas were found on both hard and soft substrate seamounts as well, with rapid compositional changes over very short distances. The last five years have added greatly to the known classes of deep-sea environments each with their own faunas: vent fields with and without soft sediments; deep-sea areas of extensive sediment transport; and seamount areas of exteme topographic variability. The experimental systems available to deep-sea biologists have multiplied, while the concept of a typical deep-sea environment has dissappeared.

I. ALVIN Supported Science Programs and Activities

b. Strategies to facilitate and assure that ALVIN supported programs have scientific excellence

ALVIN supported science has been excellent. The strategies that have assured this excellence include peer and agency review of proposed scientific programs and a special ALVIN appropriateness analysis conducted by the ALVIN Review Committee. These strategies will continue into the future since public agency review of science support decisions will continue. The mechanism for future ALVIN Review Committee activities may evolve, but peer group advice on ALVIN scheduling and use will continue. These matters are discussed further in Section 3 of this report.

I. ALVIN Supported Science Programs and Activities

c. Projections and trends (through the next decade) in submersible science, and their relationship to the ALVIN

There are important geologic, biologic, chemical and physical oceanographic problems in sea floor areas shallower than 4000 m that have not yet been investigated with ALVIN. Many of these objectives lie in logistically remote areas of the oceans or in physically harsh environments and as such were not able to be investigated with the LULU/ALVIN system.

At the present time we envision that the next decade of ALVIN exploration will greatly expand the existing oceanographic data base by collecting in situ samples and making visual observations of the sea floor in new tectonic regimes over a wider geographical area of the world's oceans.

Geology has used the largest percentage of ALVIN dive time and has been the basis for selecting dive areas throughout ALVIN's history. Thus, it appears likely that geological research will continue to play a major role in the ALVIN program. Man's understanding of sea floor plate boundary interactions is limited. Much of the high-resolution Sea Beam or side-looking sonar data acquired to date indicates that the along-strike character of plate boundaries is variable and complex. In the coming years we will need to determine how small-scale sea floor topography and structures integrate spatially to create the endemic tectonic fabric of various plate boundaries. Those data will, in turn, provide marine scientists with the necessary constraints to select and refine models for sea floor spreading processes and plate boundary kinematics. In addition, we will have to further study older sea floor, off-axis of the Mid-Ocean Ridge (MOR) to gain a clearer perspective of paleo-accretionary processes and cycles, and the temporal evolution of sea floor.

The use of ALVIN is deemed critical to our ability to understand all aspects of the geology of tectonically active areas. In situ observations and measurements will be essential to the study of dynamic sea floor and ocean crustal processes.

So far, ALVIN has investigated only field areas localized along segments of slow- to medium-spreading rate ridge crests. Field studies on the Mid-Atlantic Ridge, East Pacific Rise (EPR) and Gorda and Juan de Fuca ridges have given marine geologists an important perspective of the morphology, structure, petrochemistry, tectonic regime and geologic processes that characterize these types of accretionary plate boundaries.

The results of recent high-resolution investigations of ridge systems in the north and south Atlantic as well as the eastern Pacific, indicate that there are important but poorly understood variations in accretion geometry along many spreading center (i.e., propagating ridges, overlapping spreading centers, small ridge axis discontinuities and asymmetries in ridge axis structure) that must be studied and sampled in situ.

One topic that needs to be investigated using ALVIN is the morpho-tectonics of fast-spreading ridge crests where the oceanic plates are moving apart at rates of 15-20 cm/yr. These areas include the East Pacific Rise between 15°S to 30°S. Several fast-spreading segments of the EPR have been surveyed using Sea Beam and side-scan sonar, hence the data base and scientific models and rationale exist for ALVIN investigations to expand upon. In addition, surface-ship remote sensing surveys have, in the past few years, collected important data from sites along the MOR crest that will serve to direct and focus ALVIN investigations of overlapping spreading centers, various types of propagating ridges and asymmetric spreading centers.

Transforms

ALVIN has investigated only three transform faults: the Oceanographer transform located near 36° N on the Mid-Atlantic Ridge, the Tamayo transform, near the mouth of the Gulf of California, and the Clipperton at 10° N on the East Pacific Rise. These investigations have studied the morpho-tectonic sea floor fabric and rock associations developed at slow to intermediate slip rate oceanic transforms.

Future ALVIN programs must be devoted to exploring the complex terrain developed at fast slipping transform faults. Portions of these features reach depths of 5-6 km and as such are not within ALVIN's current diving range, however, there are areas shallower than 4 km that will be important to study with ALVIN. These areas are characterized by wide zones of complex sea floor fabric, pull-apart basins within the transform zone that may accommodate some "leaky" accretion, and strike-slip strands between the basins where much of the transform motion is concentrated. Visual observations and in situ sampling from ALVIN are essential to solve the complex geologic problems posed by the existing remote-sensing data.

Seamounts

Relatively few seamounts have been studied using ALVIN, however, sea floor volcanoes have proved to be an important component of oceanic volcanism. The structure, petrochemistry and evolution of seamounts near the East Pacific Rise crest are currently being studied in terms of magma chamber geometry and dynamics and the relationships of seamount magma chambers to rise axis magma chambers. The evolution of seamount lavas in relation to aesthenospheric melting sources for Mid-Ocean Ridge lavas is an important problem requiring precise sample acquisition that can only be carried out with ALVIN.

Future seamount studies will involve investigations of young volcanos in the western Pacific, Marianna's back-arc basin, southwest Pacific mini-plates, and south Atlantic. In addition, we suggest that older seamounts and guyots of the western Pacific may be important dive objectives for the study of global sea-level changes and ocean paleoenvironment.

Back-Arc Basins

No submersible studies have been carried out in back-arc basin locales. A considerable amount of ship time has been devoted to remote sensing studies of these tectonically complex and interesting areas, however, our understanding of the plate kinematics and detailed morphological and structural fabric of back-arc ridges and transforms is limited. In addition, the similarities between many ophiolite sequences and drilled or inferred crustal sections of back-arc oceanic crust suggest that detailed ALVIN observations and sampling of back-arc basin volcanic features and rocks will be an important objective for future research. In addition, the geochemistry of hydrothermal vents in back-arc basin spreading centers will also be critical to our understanding of global accretionary processes, hydrothermal processes and world ocean chemical balances.

Continental Margins

Given the relatively restricted geographical range of the ALVIN/LULU system only a few types of continental margins had been investigated until 1983. These studies were principally located along the U.S. east coast, in submarine canyons or on the continental slope, and focused on problems relating to canyon formation, sediment dynamics, and margin subsidence.

Since 1983 ALVIN has investigated the active structure at the toe of an accretionary prism off Oregon. This research heralds a new chapter in ALVIN's research. With the ability of the ALVIN/A-II system to travel to remote, interesting continental margins the types of margin-related research will increase. The types of problems that could be addressed include: 1) submarine canyon/continental slope processes off active margins, detailed sampling of exposed accretionary prism sedimentary rocks in the canyon cuts, stratigraphy and subsidence processes; 2) ocean floor vent processes and geochemistry in various plate settings; and 3) coastal sediment transport, continental slope and abyssal sediment dynamics and slump processes on oceanic islands and active margins.

Deep Sea Biology

In deep sea biology, the next five years will see careful exploration of the hypothesis that archaebacteria live in, and change the chemistry and lithology of, the earth's hydrothermal plumbing system. Patterns of birth, dispersal, recruitment, growth and mortality imposed on animal populations by vent evolution as it varies among different vent fields will be documented. Tracer experiments will continue to provide valuable data on bioturbation and its stratigraphic and chemical consequences. ALVIN-deployed and manipulated experiments will allow careful dissection of the kinematics and dynamics of deep-sea succession. The role of hydrodynamics in structuring faunas of both hard and soft bottoms will be explored.

II. Management and Operations of the ALVIN System

Summary

ALVIN is managed by the Woods Hole Oceanographic Institution (WHOI) and is operated as a national facility as part of the University National Oceanographic Laboratory System (UNOLS). The requests for time on ALVIN exceed supply by a ratio of 2 to 1. The development of the ATLANTIS II as a ALVIN support ship has been an unqualified success, not only are deep submergence research dives now possible throughout the world ocean, but also the ship board instrumentation on A-II, particularly the Sea Beam, has made scientific diving more efficient than was previously possible. At sea, logistics from A-II are safer and much less weather dependent than before. However, technological problems remain to be solved. Navigation, video camera systems, and sonar systems, have been improved during ALVIN's lifetime, but additional improvements are still possible. The committee recommends several. In particular, the ALVIN's manipulators are woefully behind current state-of-the-art, and require immediate major renovation. Recent renovations of the data logger, still camera systems, propulsion system, and scientific payload capability may correct the problems those systems have demonstrated during the last few years.

II. Management and Operations of the ALVIN System

Discussion

a. Management/Operations of ALVIN

b. Management/Operations of the ATLANTIS II

The Woods Hole Oceanographic Institution (WHOI) operates R/V ATLANTIS II and DSV ALVIN as a national facility under the University National Oceanographic Laboratory System (UNOLS).

Requests for ALVIN dives exceed the time available by a ratio in excess of 2 to 1. Projects to be scheduled for ALVIN dives are reviewed by federal funding agencies then analyzed for ALVIN appropriateness by the ALVIN Review Committee (ARC). WHOI then develops a schedule to accommodate recommended projects with a view toward the time or season requested, logistics, weather, and efficient transits.

Once the proposed schedule has been reviewed by the ARC and approved by the Funding Agencies, WHOI is charged with carrying out the schedule. Minor changes and adjustments are made as necessary to accommodate exigencies that may arise. Major alterations are subject to review by federal agencies and the ARC. Some factors involving major alterations are: delays due to casualties, denial of foreign clearance, addition or deletion of a project due to funding agency request.

Funding of ATLANTIS II and ALVIN is provided through a joint agreement among NSF, ONR, and NOAA. Additional support from other agencies or organizations is supplied on a use basis at a daily rate calculated by dividing the projected costs for the year by the operational days as shown on the first firm schedule. This fixed operational day rate is also the basis for determining costs assigned to the joint funders.

Operational Problems

The first two years of ATLANTIS II/ALVIN science missions brought some facets of the operations into clearer focus.

The initial schedule was compressed to absorb delays in the completion and commissioning of the hoist system. Little latitude remained for adjustments to accommodate maintenance problems or cruise extensions for scientific demands. On some occasions, it was difficult to complete the necessary logistics during the scheduled port period.

The ALVIN User's Manual has become obsolete and needs to be rewritten. Inaccurate information in the current manual has led to development of some science instrumentation that does not fit the submersible. In such situations the at-sea team must overcome the interface problems. Although considerable ingenuity, material, and fabrication resources exist aboard

ATLANTIS II, it is a costly way to fit sampling gear to the submersible.

On eleven of 29 working legs the science berthing was not fully occupied. However, there continues to be interest in increasing the number of berths for the science party. During the 1986 maintenance period, a four bunk stateroom is being developed from the electronics workshop. This will bring the total science berthing to 20 (including two in Chief Scientists room). Of this number, one is frequently assigned to a medical technician. Sea Beam personnel are also part of this group.

II. Management and Operation of the ALVIN System

c. At Sea logistics and operations

ALVIN/A-II Operations

The operations of the ALVIN/A-II system over the last two years has been an unqualified success. The unique capabilities of the launch and recovery system (including speed, ease of operation, safety, weather independence), the investigative and navigational strengths of the Sea Beam, the high present and predicted use rate of ALVIN, and the physical and operational characteristics of A-II suggest to us that A-II should be effectively dedicated to ALVIN operations whenever the submersible is available.

Ancillary Programs

A-II is well-equipped to handle most types of ancillary experiments during non-diving hours. Dredging, camera towing, hydro-casting and coring can all be accommodated. As previously mentioned the Sea Beam has proven to be extremely useful in locating and navigating dredging and camera operations.

II. Management and Operation of the ALVIN System

d. Technology within the ALVIN and A-II to support science: trends, developments, needs, and availability.

ALVIN's scientific success has been based on its early appearance as a submergence research vehicle and a continuing program of modifications and improvements intended to maximize its capability and reliability within the constraints of current technology and available funding. Little of the ALVIN constructed 21 years ago remains today, most having been replaced by newer designs in an attempt to remain state-of-the-art. This effort must continue and be accelerated since ALVIN's history demonstrates that its success depends upon remaining abreast of current technology both operationally and scientifically. The following are areas of immediate importance:

Navigation

Accurate ALVIN bottom navigation has relied on the ALNAV long-baseline transponder navigaton system since its development more than 10 years ago. Recent changes in both the transponders and surface electronics have resulted in decreased operational problems and costs per deployment but further work is required. The system should be upgraded to include improved data display functions including the ability to superimpose the ALVIN track on a Sea Beam map. Additionally, the existing limited navigation equipment located within ALVIN should be improved with the goal of providing the same information to the pilot and diving scientists as is available on the surface.

When using the ALNAV system it is critical that the deployment of the ALNAV net be coordinated between the scientific party and the ALVIN team. The scientific crew is in possession of the best sea floor maps to install a transponder array. If the ALVIN crew are required to deploy the net without the assistance of the science party, there is the potential that the net will not be in the most advantageous position or geometry, thereby limiting the effectiveness of the array and creating a situation where valuable diving time may be lost in repositioning or resurveying the net. Past experience has shown this to be the case and the ALVIN operation team deems it important to have the hands-on assistance of the science party when deploying an ALNAV net.

Investigation of alternative navigation systems should be encouraged since the addition of Sea Beam and Global Positioning System to ATLANTIS II may have changed the requirements allowing use of less complex or expensive systems. As an example, an improved short-baseline system on ATLANTIS II coupled with a refined version of the submarine mounted intermediate-baseline system recently developed and tested by the ALVIN Group appear capable of providing acceptable accuracy for the majority of ALVIN dives at a third of the present navigation system deployment costs. We also suggest that the capability to display Sea Beam data on the navigation monitor be factored into the system design so that the ALVIN track could be overprinted on the high-resolution bathymetric base. In addition, short-baseline navigation systems (e.g., Honeywell 904) such as those used for positioning offshore oil platforms and like the one utilized by the U.S. Navy for navigating SEA CLIFF, should be acquired so that when ALVIN is working in depths of 3000 m or less these systems could be used.

Film/Video Camera Systems

The process of upgrading ALVIN's camera systems must be continued. The present video cameras are insufficient in both number and quality to permit detailed analysis of sea floor features, either geologic or biologic. The manipulator held color video system developed during 1985 is an immense improvement but it should be accompanied by an equally small or smaller film camera to provide greater resolution. The large area flash video equipment successfully tested on ALVIN four years ago should be permanently installed to assist users in placing detailed observations in the context gained from a more distant view.

Lighting systems should be improved particularly now that increased battery power is available as a result of propulsion and power changes made during the 1985/1986 ALVIN overhaul. An increased number of lights plus better placement might allow effective use of more color cameras or increased resolution black and white cameras.

The video display and recording systems with data overlay capability added to ALVIN in 1984 represented a major step forward but improvements remain possible. At present, only one video tape recorder is provided on a normal dive due to space considerations but this and the small number of display monitors available limits system usefulness. As examples of how improvements might be made, video tape recorders are now available having better quality and considerably smaller size than the one presently in ALVIN. In addition, flat panel video displays are available intended for limited space applications and a CTFM sonar system compatible with that in ALVIN has recently been developed which utilizes a standard color monitor allowing data overlays and use for other display purposes.

The quality of the data overlay on the current video image (i.e., time, depth, heading, dive #, temperature navigation coordinates, altitude) needs to be improved. It is difficult to read these numbers while viewing the video. The data overlay is critical to the accurate study of the video images (e.g., strike of certain features, object size, location, etc.).

The voice track on the video should be of better quality and should include unidirectional microphones of the best quality so that extraneous submersible noise (in ball and hydraulic) is reduced or eliminated. In addition, a microphone should be placed by each observer's viewport and the ability to record observations from each scientist on separate channels should also be incorporated into the system design.

The video tape editing/duplicating system on A-II is adequate, however, at least two additional recorder/monitor systems should be available for playback of dive tapes by scientists.

Sonar Systems

The advent of Sea Beam and high-resolution sea floor maps has changed the requirements for ALVIN's sonar systems. It is now possible to navigate dive traverses using bottom depth measurements provided they are of sufficient accuracy. Additionally, high frequency scaning sonar profiling systems have become available for mounting on ALVIN which would allow filling in selected areas of a bottom map with greater detail as the result of a single submarine transit. Upgrades of this nature which greatly increase the amount of data collected during each dive are highly encouraged.

The discrepancy between depth sensors on ALVIN and their accuracy and reliability have been a moderate source of problems for ALVIN scientists and pilots. There will always be numerical difference between the acoustic and pressure sensors. However, with the advent of Sea Beam and high resolution sea floor maps to conduct ALVIN dive traverses, the accuracy and precision of ALVIN depth sensors should be maximized.

Propulsion and Power Systems

During recent ALVIN operations it became clear that the ALVIN propulsion system was tired and outdated. In addition, the power supplied by the aging batteries was not sufficient to conduct long-duration dives or those requiring extended manipulation activities or bottom photography. These problems are to be dealt with during the 1985-1986 overhaul. The committee is hopeful that they will be solved so that maximum scientific output can be achieved from each dive.

Manipulators

ALVIN's manipulators are antiquated and in serious need of replacement by state-of-the-art systems. Both the dexterity and sensory feedback should be upgraded. There are manipulators commercially available that may be well suited for use on ALVIN and the adaptation of these systems should be given high priority.

Datalogger

A finalized version of the Datalogger is to be installed during the 1986 ALVIN overhaul. This new system should eliminate or reduce the problems associated with the prototype unit in use during the 1984 and 1985 cruises. At a minimum, the new system should be simplified, include a reasonable level of self diagnostics and, if possible, be designed for complete replacement rather than trouble shooting in the event of a breakdown.

Future effort must be placed in developing user friendly computer software for allowing effective use of the recorded data. A simple method must be available for transposing the ALVIN data disks into a format useful for the majority of scientists. Additionally, the recorded ALVIN engineering data should be routinely analyzed for performance information which might allow discovering and correcting problems before dives are effected.

Still-Camera Systems

The ALVIN 35 mm bow camera system has consistently produced photographs of the sea floor that have been most useful for scientific study. This system has generally been reliable, however, we recommend that sufficient spares or replacements be acquired for cameras and strobes. The hand-held 35 mm cameras used by the observers are old and should be replaced with motorized bodies that possess a data frame capable of recording time and date on the image so that the hand-held photographs can be accurately integrated with the other dive data.

We feel that it would be important to have an automated film-strip processor on A-II for development of test strips of bow camera film. This would serve to confirm the correct operation of all 35 mm cameras so any malfunctions could be corrected before the next dive.

Payload

ALVIN carries most of its scientific sampling equipment in a releasable basket mounted on the front between the manipulators. Recent years have seen a tremendous increase in the amount of equipment intended to be carried on each dive and in many cases, the weight restriction of the basket has been the limiting factor. ALVIN design changes intended for the 1985/1986 overhaul will increase the total payload capability but the science basket limitation results from frame structural considerations which will not be changed. It is recommended that engineering be initiated to determine what changes can be made to allow effective scientific use of the planned payload increase and how science basket payload can be increased in the future.

Rescue/Survey Equipment

The ALVIN Group has developed a rescue plan for use in the event that the submersible becomes trapped on the bottom. The plan requires the use of A-II's trawl wire and winch to tow a vehicle designed to contact and attach itself to a rescue cable and buoy on the submarine. Recent operations conducted by Woods Hole's Ocean Structures and Mooring Laboratory have demonstrated the feasibility of this approach and changes have been made to the submarine during the 1985/1986 overhaul to allow the addition of the required buoy. At present, the towed vehicle does not exist but it is envisioned as a heavy pipe frame which can be navigated using the ALNAV system and would include lights to allow the submersible's occupants to assist in positioning maneuvers during its final mating approach.

Development of this system in the shortest possible time is highly encouraged and additionally, it is suggested that consideration be given to including cameras and controllers such that the towed vehicle provides a photographic survey capability permanently available aboard ATLANTIS II. Its use in this manner by the ALVIN operations team would provide the practice required for a successful rescue operation while providing valuable and inexpensive scientific capability.

III. ALVIN Program Planning, Oversight and Review Procedures

Summary

ALVIN program planning, oversight and review is currently carried out through complex interaction between the ALVIN operating group at WHOI, federal science and facilities program managers, a University National Oceanographic Laboratory System (UNOLS) appointed ALVIN Review Committee, and, through requests for intent letters and workshops at major ocean science meetings, and the ocean science community itself. This system has worked reasonably well as evidenced by the scientific success of ALVIN based science. The wider ranging science made possible by development of the A-II as the ALVIN support ship demands longer range planning and greater efforts to involve the best science possible irrespective of past ALVIN use.

The Special ALVIN Study Committee recommends that the ALVIN Review Committee be expanded and renamed the ALVIN Advisory Committee retaining its role in the scheduling process through a scheduling subcommittee and that two new standing subcommittees be established, one to be an ALVIN Long Range Planning Subcommittee, the other to be an ALVIN Technology Subcommittee.

The Special ALVIN Study Committee's review of data archiving procedures and relationship of ALVIN to federal agencies concluded with recommendations to continue a procedure recommended earlier by the ALVIN Review Committee, but not fully implemented.

III. ALVIN Program Planning, Oversight, and Review Procedures
ALVIN Review Committee

a. Policies, procedures, practices, membership, and scope of responsibilities,

b. Annual scheduling process,

c. Long range planning, and

d. User access

The ALVIN Review Committee (ARC) is composed of scientists who represent the range of marine studies undertaken by DSV ALVIN as well as a broad spectrum of the academic user community. Its advisory role has evolved over the 10 years of its existence and with changes in the scope of the program. With the mating of ALVIN to a support ship of extended range, the program has become truly global in scope, and it must be asked whether the ARC and its present mode of operation are appropriate for this new scale of operations.

At present, the scope of the ARC includes: (1) annual review, prioritization, and scheduling of dive requests; (2) long range planning; and, (3) other matters such as scientific advising of the management team, and interacting with other submersible programs. In general, the special ALVIN Study Committee feels that the ARC had done a good job in overseeing the ALVIN program but that it suffered from some problems of perception by the user community and that the ARC and its procedures may require modification to ensure a future of excellence in U.S. submersible science.

Annual Review Function

The ARC annually reviews dive requests for the suitability of ALVIN use in proposed research. The objective is to produce an operating schedule for consideration by the agencies and management team. Several problems seem unavoidable during this procedure. First, the review process entails a prioritization of requests, which includes aspects of scientific assessment. Not only does this appear to some users to be a form of "double jeopardy," but it also can only be applied very unevenly. Almost all research conducted with ALVIN is supported by the NSF, ONR, and NOAA under the three-agency agreement. Each agency has different missions, different proposal formats and different methods of determining suitability of proposed research. Moreover, the timing of their proposal reviews is such that the ARC at its annual meeting in May must review both funded and unfunded proposals. In addition, ARC also comments on the appropriateness of the number of dives requested for the proposed research and looks for situations in which separate research proposals might be integrated to save dive time and strengthen investigative capability.

Faced with these constraints and uncertainties, the ARC must, and has, come up with tentative schedules for presentation to the funding agencies. This schedule takes into account operational logistics as well as agency funding decisions and is made with the knowledge of, and interaction with, agency representatives. Clearly these schedules are only a recommendation, and both program-managerial decisions and subsequent events serve to modify them many times as each year progresses.

Analysis

Major questions about the ARC review processes have been: Is it redundant in that a funded proposal is automatically scheduled at some time? Is there double jeopardy involved? Is it an efficient use of ARC time? Does it impede user access?

The basic answer to the first question is that the management group needs some scientific input to help them create a schedule, and the ARC was the preferred alternative. If it were not for the fact that the ARC is composed of peer scientists, community complaints about trimming of number of dives, postponements, and rescheduling would probably be more severe. The perception of "double jeopardy" by some users might be muted if the advisory role of the ARC were made known more clearly to the community. There is no doubt that the ARC does exert some scientific influence on the allocation of ALVIN time, by suggesting number of dives, by suggesting integration of programs, and by feedback through program managers, who attend the ARC meetings. Nonetheless, the decisions are made by the agencies, as has been amply demonstrated over the years.

Perhaps even louder, and more focused criticism has been leveled at changes in the initial schedule, and an equitable procedure must be formalized. Since the ALVIN management team resides at the Woods Hole Oceanographic Institution, the lack of a formalized mechanism for dealing with rescheduling de facto gives WHOI users an unfair advantage in the form of the ease of their informal access to changing ALVIN schedules. No ill intent is ascribed to the managerial group, even by the disadvantaged, but rescheduling does appear to short circuit necessary re-evaluation of the scheduled science. The managerial group and the facilities managers of the funding agencies automatically get involved, but science program managers do so more rarely, and ARC opinion is almost never solicited. Consequently, rescheduling can be done with overemphasis on logistics and underemphasis on science. Simply because logistics demands rescheduling, it should not automatically determine the manner in which the science is rescheduled. Reduction by one dive can be fatal to scientific success in some programs but not in others.

Problems concerning user access appear illusory or exaggerated. There is not a closed clique that both uses and controls the use of ALVIN. The ARC is predominantly composed of people who are currently non-users. If a relatively small group of scientists has a disproportionate fraction of ALVIN dive time it is because they are more interested in submersible science and are more successful in obtaining funding from the agencies. Some "outsider" proposals fail because they are poorly conceived; unfortunately this may be a result of lack of background in submersible science. To a degree this is unavoidable, but such scientists might attempt to "break into" ALVIN use by being participants in other funded programs. The problem of demonstrating knowledge of, or proficiency with, sophisticated tools is not unique to ALVIN proposals.

A potentially more serious problem is to attract segments of the oceanographic community that, heretofore, have felt that ALVIN was too restricted to be used in their research. The new global capability of the A-II/ALVIN package opens the door to potential users who didn't bother considering ALVIN earlier. Rather than trying to keep the user group small and possibly more manageable, the agencies ought to try to attract the very best science to this very limited facility.

Proposal

The Special ALVIN Study Committee uniformly felt that the ARC should retain its role in the annual review process. Not only is this group best qualified to provide an objective and relatively neutral assessment, but if it is to be involved in longer range planning, it will also provide continuity from the advanced planning to annual scheduling. Misconceptions as to its role could be allayed by stressing to the user community the advisory nature of the ARC.

The Special ALVIN Study Committee recommends that the ALVIN Review Committee be renamed the ALVIN Advisory Committee. This change will emphasize the committee's advisory role. Although it would be better if a funding decision on all dive requests had been made before the May review meeting, it was felt that the current funding pattern is unavoidable and that the present iterative scheduling is manageable.

To prevent future problems with rescheduling after the ARC's annual meeting, a more formalized procedure appears necessary. It is recommended that the user and the cognizant science program manager (as distinct from agency personnel concerned with logistics) be contacted by telephone or electronic mail as soon as the possibility of a schedule change is raised by the management team. The need for this three-way communication is acute when scheduling changes jeopardize experiments already in the water, and the initial proposal may well be out of date when rescheduling is considered (so it may offer little guidance to either science or ALVIN managers). Without involvement of these parties there may be overemphasis on short-term logistics and underemphasis on long-term costs, both logistical and scientific. Should the program manager desire them, ARC members probably would be willing to provide additional inputs on sensitivity of the proposed science to these changes. Electronic mail is a particularly effective tool for getting such responses with minimal delay.

Long Range Planning

In the early days of the ALVIN program, the combination of depth and range limitation, together with lack of familiarity by most oceanographers created a small, user driven program. After ALVIN's increased depth capability and then the replacement of LULU with A-II, a much broader operating area and greatly expanded community of potential users has been created. No longer is it possible to let the schedule simply develop from dive requests on hand. Scheduling dive programs in widely separated areas as well as integrating new programs with the need to return to earlier stations at preset intervals becomes extremely difficult, and the program was in danger of becoming "directionless". Compounding the problem are changing user patterns and types of objectives.

A longer term planning role has been assumed by the ARC out of necessity but in a rather casual, ad hoc way. The immediate impetus was the proposal by the ARC to undertake a western Pacific program. This proposal was presented to the community by means of a call for letter proposals and by a workshop preceding the fall 1983 AGU meeting. Such workshops have become institutionalized over the past years and expanded to a second series at the AGU-ASLO Ocean Sciences meetings better to serve the chemical and biological oceanographic community. Inputs from these workshops and from letters of intent have been used for the past two years to aid in planning up to two years in advance, but long-range planning by the ARC is still a very new and fluid process.

Analysis

With the advent of the A-II, long range planning is imperative and critically important for the ALVIN program. The new global capability will inevitably involve international projects, for which 3-4 years of lead time will be necessary. The constraints that such projects will put on the schedule are large and obvious, with the equally obvious corollary that the planning function will become a controlling factor in the ALVIN program. Two styles of science have evolved with ALVIN. One is exploratory and observational, driving ALVIN to new and exciting, but often logistically difficult, locations. The other is experimental or involves time-series observations requiring ALVIN to return to sites on a specific schedule. Without long-range planning, these two approaches lead to severe scheduling conflicts.

Because the ALVIN program constitutes the bulk of the U.S. deep submersible capability, the facility must be used at the cutting-edge of marine science. We must find ways to solicit the best ideas from both these styles of science and to mold them into the best possible program. This is particularly difficult because ALVIN usage is multi-disciplinary, and the user groups have quite different criteria for project selection. Workshops have been used but these may not be efficient and may not represent the entire community. To date the ALVIN workshops have been as much a review as a discussion of possible future work. Solicitation for letters of intent has brought out additional ideas.

Another serious question is in whom the responsibility and authority for planning ought to be vested. Should the ARC as presently constituted continue in this role or should an "ALVIN Planning Committee" (APC) be generated. Such an APC might include ARC liaison representatives as well as representatives of the agencies and the management group. Should it be effectively the controlling body of the program, as the Planning Committee of the Ocean Drilling Program controls that undertaking? Finally, how is long-range planning to be implemented, and how would it lead to the scheduling function?

Proposal

The Special ALVIN Study Committee considered two modes by which the long-range planning function could be carried out. The first was a "top-down" mode of planning by which an informed executive committee of scientists, science managers and logistics personnel would put together a plan into which individual proposals could be meshed, much like the Planning Committee of the Ocean Drilling Program. The other was some modification of the present "bottom-up," proposal-driven planning.

After much discussion, it was determined that a top-down plan was unworkable. ALVIN science simply involves too many agencies (with differing missions) and scientific specialties within each agency to form a representative steering group for long-range planning. The problem with using the present ARC in long-term planning, on the other had, is the inexperience of the most recent appointees and lack of expertise on particular long-range issues.

Consequently, the committee recommends that an additional day be added to the present annual scheduling meeting for long-range planning purposes, with members being added and deleted to form an adequate review body for an "ALVIN Planning subcommittee". Care needs to be taken to represent advocates of both exploration and revisitation science. To insure community input, a clear statement must be issued annually to potential users to the effect that they will drive the long-range planning effort and determine the geographic operating areas of ALVIN. The preferred mode of input is via planning letters solicited for annual review but covering as far into the future as one cares to predict the course of science. Based on these inputs it may be appropriate to convene workshops ("gatherings of experts") on particular problems requiring repeated sampling at one site or on collections of problems in particular environments and geographic operating areas. With sufficient warning such workshops can be held at minimal expense in conjunction with annual societal meetings. Finally, the long-range plans as developed by the scheduling subcommittee should be transmitted to the user community at least three years in advance. Such timely notification of operating areas will allow individuals who did not submit initial letters of intent to recognize and respond to opportunities offered by the general ship's track. The locking out of individuals by a schedule set at a relatively early date by existing proposals has been one of the most serious objections to the present system.

Continuing Equipment Upgrade

There is continuing need to maintain and upgrade the technology employed by ALVIN and ATLANTIS II if the U.S. is to continue to lead in productivity of first-rate science from submersibles. At present, the ALVIN management group has sole responsibility for this aspect of the program and is to be commended for their success in responding to the immediate needs of the user community. However, guidance in the development of major new capabilities must come from the scientific community as part of long-range planning. It is recommended that the ARC establish a formalized mechanism for providing this guidance.

Analysis

The ALVIN management and engineering team is uniquely qualified, through twenty years of experience, to maintain the submersible in the highest technological state possible within the funding constraints. The fact that ALVIN remains the premier submersible vehicle for deep ocean research attests to their success. The efforts of the ALVIN team are primarily directed at near term problems identified by operational experience or by requests from funded and scheduled scientific users. Major technological improvements of importance to future users are frequently not identified in time to allow a reasonable development effort with the result that the inadequacy of prototype and/or existing equipment and techniques is demonstrated only a few cruises before the newer equipment becomes fully operational. Clearly, identification of required technological developments must be part of the long-range planning efforts. Therefore, the Special ALVIN Study Committee recommends that a standing ALVIN Technology Subcommittee be convened by the ARC, probably in series with the ARC annual meeting or with the societal meetings, to include representatives from the Long Range Planning and Scheduling Subcommittees as well as experts in technologies currently under consideration. The purpose of this subcommittee would be to advise the ALVIN Group and its principal funding agencies in the areas of major technological developments considered to be important for future research activities.

III. **ALVIN Program Planning, Oversight and Review Policies**

e. Data archiving, storage, "ownership"

The ALVIN operations group has established procedures for archiving and storing data routinely collected by ALVIN's cameras, video recorders, and data logging systems. These procedures are described in the ALVIN users manual. Basically these procedures assure that originals of all data are retained in the operating institutions archives with the Principal Investigator receiving one copy before leaving the cruise (i.e., the data is copied on board). The Principal Investigator retains exclusive control over use and disposition of this data for one year after completion of his cruise. The Special ALVIN Study Committee views this data policy as fair and recommends its continuance.

The ALVIN Review Committee recommended "Interim Procedures for Curation and Disposition of Samples Collected from ALVIN" in April 1979. These procedures specify that all samples are to be curated on board ship with records promptly supplied to the operating institution, and that actual samples remain in the possession of the Principal Investigator for one year after the end of his cruise. After one year, geological samples are to be sent to an established national repository...(WHOI, L-DGO, SIO, Oregon State, University of Washington, Hawaii, USC or others as may be established). Biological samples remain under the control of the Principal Investigator for three years and then are to be offered to a recognized repository such as the U.S. National Museum. Water samples remain indefinitely under the control of the Principal Investigator who collected them.

The recommended procedures for sample disposition are not a formal part of ALVIN's operating procedures, and anecdotal stories of ALVIN samples residing in private garages, university building basements, etc., are rife within the community. The Special ALVIN Study Committee recommends that the sample curation and disposition procedures developed by the ALVIN Review Committee in 1979 be formalized as a part of ALVIN operating procedures.

III. ALVIN Program Planning, Oversight and Review Policies

f. Roles and relationshps with federal agencies

The ALVIN program seems to have an appropriate role and relationship with federal agencies. The tripartite (NOAA, NSF, ONR) funding arrangement appears cumbersome, but proves to be quite workable in practice. All three agencies appear well pleased with the current operation. The major weakness identified by the Special ALVIN Study Committee was the lateness of funding decisions effecting some of the scientific projects that utilize ALVIN. For example, in December 1985 the ALVIN is tentatively scheduled for more than a month of time in the summer of 1986 that has not yet been funded. Similar examples occur every year. The Special ALVIN Study Committee recommends that firm funding decisions for science requiring ALVIN use in the next year be reached before October 1, of the preceding year so that a firm schedule can be planned at least three months before it is to begin. Scientific Programs for which funding decisions cannot be reached prior to October 1 would not be included in the next calendar year schedule. Establishment of a "drop dead date" of October 1 should greatly ease the problems of sequential rescheduling that have plagued ALVIN operations in recent years.

IV. Additional Issues

Summary

The Special ALVIN Study Committee briefly evaluated the technological context within which the ALVIN program operates in 1986. This evaluation involved a review of ALVIN's relationship to the U.S. Navy scientific submersbile program, as well as with non U.S. programs. The evaluation also considered ALVIN's technological context by reviewing developments in industrial use of submersibles and the shallower depth research submersibles operated by the Harbor Branch Foundation and others.

The Study Committee recommends continuation of the growing linkage between the ALVIN program and those of other submersbile operators including the new science programs being developed for U.S. Navy and foreign submersibles. Further, it recommends that an in depth review of submersible technology be undertaken as part of a major new Submersbile Science Study that is recommended for 1986.

IV. Additional issues

Discussion

a. Relationship of ALVIN program and Navy submersibles, particularly, SEA CLIFF, TURTLE, NR-1, DOLPHIN

The U.S. Navy has several research submersibles that have been used by members of the U.S. science community since the mid-1970's. These vehicles include, SEA CLIFF, TURTLE, and NR-1. SEA CLIFF has recently been converted to a 6200 m depth diving capability, although at present no suitable launch and recovery platform exists to transport and deploy the submarine in areas greater than 150 miles from San Diego, CA. TURTLE had been converted to a 3100 m diving capability, although because of a fire during 1984 this submarine is presently out of commission. It is, however, being rebuilt and should be back in service by mid to late 1986. The same lack of adequate support vessel applies to TURTLE as well as SEA CLIFF.

NR-1 is a nuclear powered submarine that can remain submerged for long periods of time (several weeks). It is equipped with sophisticated sonar and positioning systems that have made it a valuable tool for mapping shallow sea floor areas.

The Secretary of the Navy has recently initiated a plan to utilize Navy DSV's for oceanographic research. The plan includes the establishment of a WHOI/SIO technical support group to assist with science operations; commitment to 60 days per year of science operations; designates ONR as the Navy's agent to validate and prioritize research projects; proposes a major, high visibility, science cruise in 1987 or 1988; establishes a user fee to help fund the support group and new instrumentation; and commits the Navy to acquire a new DSV support ship capable of world wide operations.

Given the great potential of SEA CLIFF as a diving vehicle, we applaud the Secretary's new effort to gain operational reliability for SEA CLIFF and access to dive time for U.S. scientists.

Because of the experience within the ALVIN Review Committee (ARC) to effectively compile and organize submersible diving schedules we suggest that the ARC assist the Navy and ONR in planning for future SEA CLIFF science diving.

As regards to the capability to launch and recover SEA CLIFF from A-II we have the following comments:

1. Based on a study made by the ALVIN group at WHOI, it is clear that substantial modifications must be made to support SEA CLIFF operations on A-II. These modifications include changes to the A-II deck, ballast, electrical and winch systems at an estimated cost well in excess of 1 million dollars.

2. A WHOI report suggests that SEA CLIFF is probably too big a submersible (both physical dimensions and weight - it is almost twice the weight of ALVIN) to be effectively supported by A-II.

3. On an emergency basis SEA CLIFF could probably be launched from A-II under very calm sea conditions, however, even this limited use would necessitate structural modifications to A-II with costs of $100K-$200K.

4. Given already heavily committed schedule for ALVIN and A-II in the coming years we recommend that the ARC assist ONR with planning for SEA CLIFF science diving, however, A-II should not be scheduled for SEA CLIFF support for at least the next 3-5 years. We think it prudent that the minor structural modifications needed to support SEA CLIFF on an emergency basis be made whenever possible, on a not to interfere basis with ALVIN operations.

IV. Additional Issues

b. Cooperation with foreign programs

The ALVIN program has successfully undertaken international, cooperative projects in the past, and will certainly continue to be involved in such projects in the future. Two types of cooperative efforts are undertaken with foreign scientists and their governments. One type involves exchange of scientific personnel and sharing of data and facilities, and is exemplified by the first major ALVIN international cooperative project, FAMOUS or French-American Mid-Ocean Undersea Study. This study used both ALVIN and the French submersible CYANA to explore the rift valleys of the Mid-Atlantic Ridge. The second type of cooperative effort usually involves invitation of a country's scientific representatives to participate in a given ALVIN expedition as either courtesy or obligation when the operations are planned in or near to that country's 200-mile Exclusive Economic Zone (EEZ) or territorial waters. The various ALVIN expeditions in recent years off the coasts of Mexico, Central and South America are examples of the latter type of cooperative project.

Future ALVIN operations are likely to take place in the Western Pacific, and it is not unreasonable to assume that scientific pressure will push operations into the South Pacific, Indian Ocean and the Mediterranean and adjacent seas in the late 1980's and into the 1990's. These projects will be remote from U.S. ports, will involve long transits between operation areas, and will certainly place new demands on the ALVIN support group and ALVIN planning and scheduling. International, cooperative projects of the FAMOUS type will be desirable under these circumstances because they provide a means of:

1. Cost-sharing the operations expenses,

2. Technology exchange via use of shared facilities and know-how,

3. Enhancement of science objectives via (A) and (B) above, and

4. Ease of operation clearance in territorial waters.

Examples of such cooperative projects that are possible in the near future include an ALVIN/SHINKAI 2000 operation in waters off Japan and an ALVIN operation in concert with the French submersibles NAUTILE/CYANA in the Southwest Pacific. Operations in foreign EEZ's will continue to require cooperative projects by invitation. In the past, such invitations have been the responsibility of WHOI in conjunction with the U.S. Department of State. This mode of clearance will probably continue in the future. Clearances may become more difficult to obtain and the possibility of misunderstanding could increase, however, when several operations are scheduled within regions of multiple EEZ's, such as within those of the island states of the West and Southwest Pacific. In such circumstances, the Special ALVIN Study Committee recommends that the WHOI work with the ARC's long range planning group and representative of international agencies, such as the Committee for Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC) and the United Nations' Intergovernmental Oceanographic Commission (IOC) in the West and Southwest Pacific, to obtain a coordinated clearance for operations in the region. The committee further recommends that that long range planning group be apprised of any international cooperative agreements to conduct submersible science involving ALVIN so that it can use this information in its long range planning and project coordination efforts.

IV. Additional Issues

c. New construction needs, submersibles and support systems

1. Submersibles

Atmospheric Diving Systems (ADS)

The technologies employed by scientific and commercial interests until fairly recent times were virtually the same. Both used similar submersibles, support ships, and diving systems. In the 1970's, however, commercial subsea operators began experimenting with alternatives. Atmospheric Diving Systems ("ADS") such as the JIM, WASP, and microsubmersible, MANTIS, were developed, as well as several remotely operated vehicles ("ROV's"). These systems offered the potential of both improved capability and lower costs.

The pressure of the market place for improved performance stimulated funding for rapid development. For example, in 1975, a pipeline inspection at a depth of 400 ft. would have cost approximately $30,000 a day for either a saturation diving system or submersible operating from dedicated, "mother ships". Today, such work is being done in less than one half of the time by third generation ADS units or ROV's, highly transportable systems operating from vessels of opportunity (already in the area) for less than $3,000 a day for equipment and personnel. Therefore, as far as commercial interests are concerned, the conventional submersible is extinct and saturation diving is used only as a last resort for special tasks, such as complex construction jobs.

In assessing the potential value of these commercial diving alternatives to the scientific community, the basic needs of science and industry should be examined.

0-150 ft. depths

In depths from the surface to 150 ft., the basic economy of the scuba diver and professional divers using helmets and surface demand systems will continue, but with the following significant qualification. The cost of inspection ROV's has recently dropped by a factor of ten from $300,000 for a basic vehicle to $30,000 (i.e., MINIROVER and PHANTOM). This dramatic trend will have a significant impact both in science and industry since it upsets the prevailing cost/performance relationship among the various alternatives -- diving, ADS, and ROV. Intense competition among ROV manufacturers will continue to fuel the trends toward lower cost and higher performance of ROV's. For example, the operating depth for a portable ROV (PHANTOM HD and SEA ROVER) has been pushed to 1000 feet, and various tools including still cameras, sonar, and manipulators are becoming available. The present day reality, unthinkable less than a year ago, is that a humble Zodiac loaded with an $800 2 KVA generator and one of the above systems becomes a 1000 ft. dive ship, able to survey, document, and sample with new found cost effectiveness. Such a system offers new possibilities both to the scientific diving community and to commercial diving companies. While such systems might be viewed as an approach that will ultimately replace divers, the reality is that they complement present diving methods, offering a new tool to extend range, time documentation, and other working capability sub sea.

150-3000 ft. depths

ADS and ROV systems presently in widespread use operate in depths of 2000-3000 feet (i.e., ADS WASP, MANTIS, DEEP ROVER, ROVE SCORPIO, RECON, SOLO, etc.). This depth is the maximum required for the great majority of work relating to the offshore oil and gas industry.

Within this depth range, some seventy manned ADS units and more than 200 ROV systems are in daily, routine operations, essentially worldwide in all conditions up to Sea State 6. Virtually all of the systems, both manned and unmanned, are portable or semi-portable, cable deployed, and operate from vessels of opportunity. Typically, work is site-specific, i.e., around a well head or template, requiring deployment from a fixed platform, anchored vessel, or dynamically positioned vessel.

Survey work ideally is done by deployment from a dynamically positioned vessel or other suitably maneuverable ship. The constraints of an armored cable/tether are tolerated because the vehicles are launched and recovered directly with cable, thus making it possible to operate in a higher sea state and eliminating the need to "jump diver". The tether also provides hard wire communication, video, and sonar information to the surface making it possible to coordinate and direct the work.

While cable deployed systems can operate from a vessel of opportunity, they are best suited to anchored or dynamically positioned vessels. Therefore, ADS use for science will favor the systems which can operate without a tether such as DEEP ROVER.

Clearly, there is a fundamental difference in the work patterns of sub sea vehicles for commerce or science. The relatively low cost ($200 - $800K), portability and reliability of the ADS/ROV enables the offshore industry to treat them simply as tools to be deployed when and how the work dictates. On the other hand, science plans long term cruises treating the submersible/mother ship as an inseparable unit where the logistics of the ship and its work area is a major factor in cruise planning. The ability of science to plan, coordinate and control such a cruise in advance, coupled with the need to sometimes work in remote areas, make such a mode of operation both viable and cost effective. Such constraints would be unacceptable to a commercial operator. Therefore, use of ADS/ROV technology should not be expected to replace the conventional submersible/mothership in science in the same way as it has in industry. Rather, it offers an exciting but very different concept for sub sea access since it has a totally different set of constraints. Basically, use of ADS/ROV technology drastically lowers the cost of "inshore" submersible operations, raises the flexibility and practicability to a level that could give access to a much wider user group.

Depths Below 3000 ft.

Until the offshore oil industry perceives a need to operate below 3000 ft. the resources that brought forth the modern ADS/ROV technology are unlikely to push that technology deeper. Therefore, technology spin off to science will continue to be at the piece-meal component level rather than total solutions. A good current example is manipulator technology. Sophisticated units with force, tactile and motion feedback are available "off the shelf" to sub sea science while being considered for adoption by NASA in space station use.

IV. Additional Issues

d. Review S^3 study

The ALVIN Oversight Team reviewed the Submersible Science Study (S^3) Report published in 1982. This report was based on review activities that began in 1979. The S^3 report provides an excellent summary of past and early 1980's research requiring submersibles, useful projections on future research that would require submersibles, and summarized submersible systems from which such research might be conducted. A major focus of the S^3 report was the need for a Submersible Support Ship for ALVIN that would replace R/V LULU.

As summarized in the preceeding section of this report, the technology for scientific research from submersibles has developed greatly since completion of the S^3 report. The ALVIN is now launched and recovered from the R/V ATLANTIS II, a support ship with global range. French and Japanese scientific research operations now have access to effective research submersibles with depth capabilities of 6000 m and 2000 m respectively (the ALVIN's capability is 4000 m). A wide spectrum of shallow water (ca. 250 m) submersibles are available for research use at charter rates much reduced from those in effect five years ago. These changes in technology fundamentally alter the range of scientific questions than can be addressed through use of submersibles. Therefore, the Special ALVIN Study Committee recommends that another Submersible Science Study be conducted in 1986. The major focus of this study should be on the scientific questions that can best be addressed through use of modern submersible technology, and the need for beginning the planning process that could lead to development of a submersible with deeper diving capability than ALVIN by the early 1990's.